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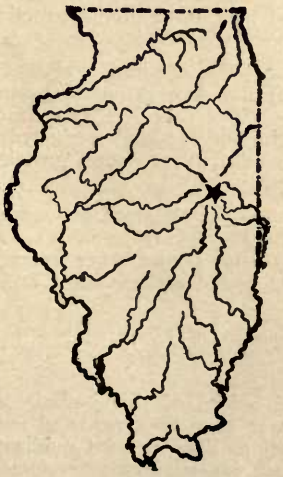
Agricultural Experiment Station

BULLETIN No. 163

THE MAINTENANCE REQUIREMENT OF SWINE

By WILLIAM DIETRICH



URBANA, ILLINOIS, JUNE, 1913

Summary of Bulletin No. 163

1. Object.—To determine the amounts of feed required for the maintenance of swine under different conditions. The maintenance ration may be defined as one containing enough of the various nutrients (protein, carbohydrate, ether extract, mineral matter, and water) to support the animal without the production of growth or of work.

2. Plan.—Pigs differing in age, breeding, and conformation were used in three successive experiments, including twenty-six separate maintenance periods, to determine the amount of feed and of the respective nutrients required for maintenance. The rations were gradually reduced during several weeks' time until quantities were reached that maintained a constant live weight. The coefficients of digestibility of the various nutrients were determined in most instances. In the last experiment, the nitrogen balance and the consumption and excretion of water also were determined to show whether the live weight was maintained by the substitution of water for body tissue.

3. Animals Used.—In the first experiment four pigs of mixed breeding were used in four separate periods at 50, 100, 150, and 200 pounds live weight, respectively. In the second experiment, three pigs were used: a Berkshire 3 years old, a Poland-China 1½ years old, and a Poland-China 1 year old. In the third experiment, two yearling Berkshire barrows were used which weighed 240 and 320 pounds respectively.

4. Rations Fed.—In Experiment No. 1, the feed consisted of ground corn, wheat middlings, and skim milk; in Experiment No. 2, ground corn, wheat bran, wheat middlings and tankage; and in Experiment No. 3, ground corn, red dog flour, tankage, and pork cracklings. The latter experiment also included a fasting period of eight days.

5. Experiment No. 1.—The apparent maintenance requirement per day per 100 pounds live weight of the 50-pound pigs was 0.121 pounds crude protein, 0.434 pound carbohydrate, 0.02 pound ether extract; of the 100-pound pigs, 0.124 pound protein, 0.517 pound carbohydrate, 0.026 pound ether extract; of the 150-pound pigs, 0.131 pound protein, 0.633 pound carbohydrate, 0.033 pound ether extract; of the 200-pound pigs, 0.102 pound protein, 0.549 pound carbohydrate, and 0.033 pound ether extract. Page 417

6. Experiment No. 2.—The apparent maintenance requirement per day per 100 pounds live weight of Pig A (509 pounds) was 0.139 pound crude protein, 0.402 pound carbohydrate, 0.032 pound ether extract; of Pig B (375 pounds), 0.112 pound crude protein, 0.404 pound carbohydrate, 0.032 pound ether extract; of Pig C (308 pounds), 0.112 pound protein, 0.401 pound carbohydrate, 0.032 pound ether extract. Page 421

7. Experiment No. 3.—The apparent maintenance requirement per day per 100 pounds live weight of Pig A (415 pounds) was 0.078 pound protein, 0.228 pound carbohydrate, and 0.029 pound ether extract; of Pig B (320 pounds), 0.084 pound protein, 0.213 pound carbohydrate, and 0.036 pound ether extract. Page 427

8. General Discussion. Pages 431-435

9. Conclusions. Page 435

Note.—The essential points of this bulletin which are of direct interest to the general swine feeder have been reported and discussed in Circulars 126, 133,[1] and 153 of this station. The present publication is a more complete and technical report of certain investigations conducted by the writer. It is not designed for the general reader, but more especially for students, investigators, and others who are contemplating or engaged in similar investigations.

[1]Out of print.

THE MAINTENANCE REQUIREMENT OF SWINE

By WILLIAM DIETRICH, Assistant Chief in Swine Husbandry

INTRODUCTION

A certain portion of the food eaten by an animal must be used for maintenance; the remainder may be used for the production of food, clothing, or energy for the use of man. If it is possible, therefore, to determine approximately the maintenance requirement, or to show that this requirement differs under different conditions, one of the necessary fundamental steps will have been taken in solving the problem of swine feeding.

The maintenance requirement may be defined as a ration containing enough of the various nutrients (protein, carbohydrate, ether extract, mineral matter, and water) to support the animal when doing no work and yielding no material product; in other words, the minimum food supply necessary merely to maintain the processes essential to life without the production of growth or of work. In this bulletin the maintenance ration is regarded as approximately the feed required to maintain the live weight of pigs without either gain or loss. The fact is recognized that the mere maintenance of constant live weight for comparatively short periods, especially by young animals, is not necessarily a trustworthy guide in the determination of the true maintenance requirement, notwithstanding the fact that up to the present time much of the available information upon this subject has been derived by such a measure. However, the length of time of the experiments here reported, and the fact that in some of them the nitrogen balance was determined, adds weight to the significance of the results obtained.

EXPERIMENT NO. 1

The first data obtained by the writer on this subject were gathered as a part of a thesis experiment[1] conducted at the University of Wisconsin under the direction of Professor W. A. Henry in 1898 and 1899. These results are given in the following discussion.

[1]A review of this experiment is given in the 16th Annual Report of the Wisconsin Agricultural Experiment Station for 1899, page 31.

PLAN OF EXPERIMENT

The data of this experiment were obtained with four pigs of mixed breeding, containing Berkshire, Poland-China, and Chester-White blood. They were the same age and nearly the same weight and were treated in a similar manner. Each one was fed by itself, but at all other times they occupied a pen in common in the hog house, with access to a small yard on the outside.

It was the plan of this experiment to start with pigs weighing approximately 50 pounds. The amount of feed required for maintenance at this point was to be determined as accurately as possible. The pigs were then to be fed up to 100, 150, and 200 pounds live weight, respectively, with maintenance determinations at each of these stages of growth and fattening.

Previous to the time of the beginning of this experiment, the pigs had been fed all they would consume readily. It was thought that by gradually reducing their feed a point would be reached where they would maintain a constant live weight, the ration at such point representing approximately the amount of feed required for maintenance; and that with a further reduction in the ration the pigs would lose in live weight. The fact is recognized that under such conditions a pig might be losing dry matter from its body and at the same time replacing it with water, so that all the facts in the case would not come to light. Nevertheless, an experiment of this kind shows the maintenance requirements so far as is possible without the use of a respiration calorimeter.

The feeds used in the maintenance periods of this experiment were ground corn, wheat middlings, and skim milk. The meal used during the first eight days of the experiment consisted of ground corn, one part, and wheat middlings, two parts. During the remainder of the experiment it consisted of equal parts of ground corn and middlings. The meal and skim milk were mixed according to the existing feeding standards, so that a wider nutritive ratio was obtained in each successive period of the development of the pigs.

Every morning before they received their feed, the pigs were weighed. Table 1 gives the quantities fed per day and the daily weights of the pigs during the four periods of maintenance feeding, except that in each case the first day of a period is the last day of the previous full-feed period.

In considering the data for the 50-pound pigs, it will be seen that the feed record starts with the 2d day. At this time the pigs received, on an average, 2 pounds of meal per day, which was a slight reduction from the full feed they had received previously. During the first 28 days of the experiment, the feed was slowly

reduced, but the average live weight of the four pigs gradually increased from 42.5 to 49.75 pounds per head. During the 5-day period from the 11th to the 15th day the pigs gained only 0.25 pound; consequently, the amount of feed received was practically a maintenance ration under the conditions of the experiment as they existed at that time.

On the 28th day the feed was reduced to 0.3 pound meal and 1.2 pounds skim milk. This was kept constant for a period of 7 days, during the first 6 of which the pigs maintained a constant live weight, but on the 7th they lost slightly; and, with a further reduction in the feed during the next 2 days, they lost still more. It is thus seen that 0.3 pound meal and 1.2 pounds skim milk were required for the maintenance of these pigs under the conditions of this experiment.

Two pounds of water mixed with the feeds in the form of slop was fed each pig daily from the 17th to the 36th day inclusive. In addition, the pigs were offered some water to drink, but they took very little, an average of only 0.22 pound per head per day.

A similar process of reduction in feed was repeated during the three other periods of the experiment. With the 100-pound pigs the maintenance ration was found to be that fed from the 11th to the 18th day. After this the feed was reduced to see whether it would cause a loss in live weight. On the 21st day there was a gain made on the reduced quantity of feed, but at this time the pigs ate some of the bedding, which is held to account for the gain in live weight. After this there was a loss in live weight on the reduced quantity of feed.

With the 150-pound pigs, the apparent maintenance ration was reached during the period from the 29th to the 35th day, and consisted of 1.6 pounds meal and 1.6 pounds skim milk. During this time, however, the pigs lost a little in live weight, which would seem to show that this ration was at least a small enough quantity. Because there was a slight loss in live weight during this period, it was not thought necessary to make further reduction in feeds, but the pigs were fed the same quantity for a longer time for the purpose of making a digestion trial.

With the 200-pound pigs, the apparent maintenance ration was reached during the period from the 22d to the 28th day inclusive, and consisted of 2 pounds meal per day, with no skim milk. This, apparently, was a little less than a maintenance ration, as the average live weight of the pigs was reduced from 201.5 to 200.75 pounds during that time.

Table 2 shows the composition of the feeds used in these tests, as determined by the writer during different periods. From these data the amounts of digestible nutrients consumed during the maintenance periods were calculated.

TABLE 1.—DAILY WEIGHTS OF PIGS AND FEEDS FOR THE FIRST MAINTENANCE EXPERIMENT
(Expressed in pounds)

Days	Period 1			Period 2			Period 3			Period 4	
	Average of four 50-pound pigs			Average of four 100-pound pigs			Average of four 150-pound pigs			Average of four 200-pound pigs	
	Feeds		Weight	Feeds		Weight	Feeds		Weight	Meal	Weight
	Meal	Skim milk		Meal	Skim milk		Meal	Skim milk			
1				3.6	7.2	105.13	6.4	6.4	155.38	6.0	211.13
2	2.0		42.50	2.7	5.4	103.25	3.2	3.2	152.73	3.0	207.13
3	2.0		43.25	1.8	3.6	101.25	3.0	3.0	151.13	3.0	206.13
4	2.0		43.88	1.7	3.4	99.88	2.9	2.9	151.23	2.8	205.75
5	2.0		43.88	1.6	3.2	100.50	2.8	2.8	151.13	2.6	205.75
6	1.8		44.13	1.5	3.0	99.88	2.6	2.6	151.13	2.4	206.75
7	1.5		44.75	1.4	2.8	100.38	2.5	2.5	151.00	2.2	205.75
8	1.5		45.25	1.1	2.2	99.39	2.4	2.4	150.00	2.0	205.38
9	1.2		45.75	1.0	2.0	99.63	2.3	2.3	150.88	2.0	205.63
10	1.0	3.0	46.25	.9	1.8	99.75	2.2	2.2	150.63	2.0	205.00
11	.8	2.4	46.50	.8	1.6	98.75	2.0	2.0	149.75	1.8	204.25
12	.8	2.4	46.63	.8	1.6	99.00	2.0	2.0	149.50	2.0	204.75
13	.8	2.4	46.63	.8	1.6	99.00	2.0	2.0	149.75	2.0	204.75
14	.8	2.4	46.75	.8	1.6	98.75	2.0	2.0	149.25	1.8	204.25
15	.8	2.4	46.75	.8	1.6	99.00	2.0	2.0	148.88	1.8	204.13
16	.7	2.1	47.25	.8	1.6	99.00	2.1	2.1	148.63	1.8	204.00
17	.6	2.4	47.75	.8	1.6	98.50	2.2	2.2	149.00	1.8	202.63
18	.6	2.4	47.75	.8	1.6	98.63	2.2	2.2	149.88	1.8	202.75
19	.6	2.4	48.38	.7	1.4	98.38	2.2	2.2	149.00	1.8	202.63
20	.5	2.0	48.50	.6	1.2	97.88	2.2	2.2	149.88	1.8	201.88
21	.5	2.0	48.50	.6	1.2	98.25	2.2	2.2	150.25	1.9	201.25
22	.5	2.0	48.75	.6	1.2	97.63	2.2	2.2	150.63	2.0	201.50
23	.5	2.0	49.25	.6	1.2	96.75	2.1	2.1	151.13	2.0	201.38
24	.4	1.6	49.25	.6	1.2	96.25	2.0	2.0	151.25	2.0	201.38
25	.4	1.6	49.25				2.0	2.0	151.75	2.0	201.63
26	.4	1.6	49.38				1.9	1.9	152.00	2.0	201.38
27	.4	1.6	49.75				1.8	1.8	152.38	2.0	201.13

TABLE 1.—*Continued*

Days	Period 1			Period 2			Period 3			Period 4	
	Average of four 50-pound pigs			Average of four 100-pound pigs			Average of four 150-pound pigs			Average of four 200-pound pigs	
	Feeds		Weight	Feeds		Weight	Feeds		Weight	Feeds	Weight
	Meal	Skim milk		Meal	Skim milk		Meal	Skim milk		Meal	
28	.3	1.2	49.75				1.7	1.7	152.38	2.0	200.75
29	.3	1.2	49.75				1.6	1.6	152.25		
30	.3	1.2	49.75				1.6	1.6	152.00		
31	.3	1.2	49.75				1.6	1.6	152.00		
32	.3	1.2	49.75				1.6	1.6	151.88		
33	.3	1.2	49.75				1.6	1.6	151.75		
34	.3	1.2	49.50				1.6	1.6	151.88		
35	.2	.8	49.50				1.6	1.6	151.88		
36	.2	.8	48.75				1.6	1.6	151.63		
37							1.6	1.6	151.88		
38							1.6	1.6	151.88		
39							1.6	1.6	151.63		
40							1.6	1.6	151.25		
41							1.6	1.6	151.63		
42							1.6	1.6	151.39		

TABLE 2.—PERCENTAGE COMPOSITION OF FEEDS

Feeds	Crude protein	Carbohydrates		Ether extract	Period in which used
		Nitrogen-free extract	Crude fiber		
Ground corn	9.84	71.72	2.42	3.91	1 and 2
Ground corn	9.73	70.91	2.39	3.87	3
Ground corn	9.44	72.01	2.01	3.65	4
Wheat middlings	16.67	56.79	6.76	4.74	1 and 2
Wheat middlings	16.62	56.61	6.73	4.73	3
Wheat middlings	17.13	52.99	6.77	5.54	4
Skim milk	3.23	4.80		.09	1
Skim milk	3.41	5.04		.12	2
Skim milk	2.81	4.43		.08	3

The coefficients of digestibility were also determined during the maintenance and full-feed periods with two of the 150-pound pigs. The averages of these factors for the two pigs used during the maintenance period are as follows: crude protein, 78; nitrogen-free extract, 85; ether extract, 76. During the full-feed period the following factors were obtained: crude protein, 76; nitrogen-free extract, 86; crude fiber, 22; ether extract, 66. The averages of these are as follows: crude protein, 77; nitrogen-free extract, 85.5; crude fiber, 22; ether extract, 71. Calculating by the use of these factors the amounts of digestible nutrients fed during the different periods, the data given in Table 3 were obtained.

From Table 3 it will be noticed that the quantities of feed required for maintenance by the 50-pound pigs were 0.3 pound meal (one-half consisting of ground corn and one-half of middlings) and 1.2 pounds skim milk; by the 100-pound pigs, 0.8 pound meal and 1.6 pounds skim milk; by the 150-pound pigs, 1.6 pounds meal and 1.6 pounds skim milk; while the 200-pound pigs were nearly maintained on 2 pounds meal with no milk, but, as pointed out above, this probably was too small a quantity.

The table shows that the 50-pound pigs were maintained on 0.75 pound of feed per 100 pounds live weight, as a daily ration, the 100-pound pigs on 0.86 pound, the 150-pound pigs on 1 pound, and the 200-pound pigs were nearly maintained on 0.88 pound. By referring to the next column it will be seen that the amount of digestible crude protein in the maintenance ration for the 50-pound pigs was 0.121 pound per day; for the 100-pound pigs, 0.124 pound; for the 150-pound pigs, 0.131 pound; and for the 200-pound pigs, 0.102 pound.

The next column gives the digestible carbohydrates daily per 100 pounds live weight. The results seem to show that the 50-pound pigs required 0.434 pound per day; the 100-pound pigs, 0.517 pound; the 150-pound pigs, 0.633 pound; and the 200-pound pigs, 0.549 pound.

TABLE 3.—MAINTENANCE RATION FOR SWINE AS DETERMINED IN EXPERIMENT NO. 1

(Expressed in pounds per day)

Weight of pigs	Feeds per head		Total feed per 100 pounds live weight	Digestible nutrients and metabolizable energy per 100 pounds live weight					Nutritive ratios
	Meal	Skim milk		Crude protein (Nx6.25)	Carbohydrates: Nitrogen-free extract	Carbohydrates: Crude fiber	Ether extract	Metabolizable energy,[1] therms	
50	.3	1.2	.75	.121	.428	.006	.020	.897	1:3.9
100	.8	1.6	.86	.124	.509	.008	.026	1.317	1:4.3
150	1.6	1.6	1.00	.131	.622	.011	.033	1.806	1:5.3
200	2.0	0.	.88	.102	.539	.010	.033	1.718	1:5.3

[1]The metabolizable energy of a ration is the energy which can be liberated and utilized in the animal body; or, the gross energy less that contained in the feces, urine, and intestinal gases. The metabolizable energy of the rations has been calculated from the amount of digestible nutrients, using the following factors:

	Calories per pound
Digestible protein	1860
Digestible nitrogen-free extract	1905
Digestible crude fiber	1588
Digestible ether extract	3992

One therm equals 1000 calories. It is generally accepted that the metabolism of the animal body is proportional to the surface of the animal, and further, that the surfaces of two animals of the same species are proportional to the two-thirds powers of their weights. Therefore, the metabolizable energy given above has been calculated on the basis of the two-thirds powers of the body weights.

By referring to the first part of the table it will be seen that the 100-pound pigs received, proportionately, a smaller quantity of skim milk than did the 50-pound pigs, while the 150-pound pigs received a still smaller quantity, and the 200-pound pigs received none at all. Since skim milk is a nitrogenous feed, it will be observed that by this method of feeding the relative quantity of crude protein in the daily ration was gradually reduced as the pigs grew older. As the last column of the table shows, the nutritive ratios of the rations were materially widened from the first to the third periods.

EXPERIMENT NO. 2

For further evidence as to the amount of feed and of digestible nutrients required for maintenance, the results of another experiment that was made during the winter of 1905-06 at this station are here given.

Three pigs, a Berkshire 3 years old, a Poland-China 1½ years old, and a Poland-China 1 year old (designated A, B, and C, respectively) were fed in separate box stalls where their feces and urine could be collected. The pigs were kept confined in these stalls except when they were taken out to be weighed and exercised in the morning and driven several hundred feet for exercise in the afternoon.

After the three pigs had been on full feed for nine days, their daily allowance was gradually reduced during a period of two weeks, so that at the end of this period they were receiving amounts of digestible nutrients that were considered sufficient for maintenance but not enough to produce material gains in live weight.

The feeds used during the full-feed period were ground corn, wheat bran, and wheat middlings. During the reduction period the ground corn and middlings were gradually reduced and the bran increased until the ration was one of bran alone. It was found, however, that all the pigs would not eat enough of an all-bran ration for maintenance; consequently, after the first few days of this kind of feeding, part of the bran was replaced with ground corn and tankage. The change was made, however, so that the total amounts of digestible nutrients remained practically the same.

EXPERIMENTAL DATA

Table 4 gives a complete record of the feeds used and of the live weights of the three pigs from the time full feed was discontinued until a week after the final maintenance period.

As is shown by the table, the pigs maintained practically constant weight from the 19th to the 29th day, such fact indicating that the amounts and proportions of feeds received at this time apparently were sufficient for maintenance. At the close of this period, the ration was reduced still further to see if this reduced quantity would result in a loss of live weight. During the first four days following this reduction, Pig A lost 2 pounds, and Pigs B and C each lost 3 pounds in live weight. On continuing this latter ration for a longer time, however, it was found that the pigs maintained their slightly lower live weights on this reduced quantity of feed without the slightest fluctuation until the 44th day. At this time they were given still another reduction in feed, but they lost in live weight from 1 to 3 pounds per day during the entire following week. This reduction of feed, however, was of considerable magnitude. It is not known whether, if this quantity of feed had been continued for a longer time, it would also have maintained the live weights of these hogs.

During the period from the 19th to 29th day inclusive, the pigs were receiving in their daily rations the following amounts of digestible nutrients in pounds per 100 pounds live weight:

Pig	Digestible crude protein	Digestible carbohydrate	Digestible ether extract
A	.15	.44	.038
B	.15	.49	.034
C	.15	.46	.035

TABLE 4.—DAILY WEIGHTS OF PIGS AND FEEDS FOR THE SECOND MAINTENANCE EXPERIMENT

(Expressed in pounds)

Days	Pig A, Berkshire, 3 years old					Pig B, Poland-China, 1½ years old					Pig C, Poland-China, 1 year old				
	Feeds used				Live weight	Feeds used				Live weight	Feeds used				Live weight
	Ground corn	Wheat bran	Wheat middlings	Tankage		Ground corn	Wheat bran	Wheat middlings	Tankage		Ground corn	Wheat bran	Wheat middlings	Tankage	
1	3.3	3.3	3.3		495	2.5	2.5	2.5		373	2.0	2.0	2.0		304
2	3.1	3.6	3.1		497	2.3	2.6	2.3		373	1.9	2.2	1.9		306
3	2.8	2.8	2.8		498	2.1	2.8	2.1		375	1.7	2.4	1.7		307
4	2.6	4.1	2.6		499	2.0	3.0	2.0		376	1.5	2.5	1.5		310
5	2.3	4.3	2.3		500	1.8	3.2	1.8		376	1.6	2.7	1.6		308
6	2.0	4.5	2.0		500	1.6	3.4	1.6		376	1.4	2.9	1.4		304
7	1.8	4.8	1.8		504	1.5	3.6	1.5		377	1.3	3.0	1.3		306
8	1.5	5.0	1.5		504	1.3	3.8	1.3		377	1.1	3.2	1.1		308
9	1.3	5.3	1.3		507	1.1	4.0	1.1		379	1.0	3.4	1.0		310
10	1.0	5.5	1.0		507	1.0	4.2	1.0		377	.8	3.5	.8		309
11	.8	5.8	.8		508	.8	4.4	.8		377	.7	3.7	.7		311
12	.6	6.0	.6		508	.6	4.6	.6		380	.5	3.9	.5		311
13	.4	6.3	.4		510	.4	4.8	.4		381	.4	4.0	.4		311
14	.2	6.6	.2		510	.2	5.0	.2		381	.2	4.2	.2		311
15		6.9			509		5.2			378		2.2			311
16		6.9			510		5.2			375		2.2			310
17		6.9			509		5.6			371		2.2			309
18		7.0			510		5.4			378	1.2	2.0		.3	308
19	1.0	4.5		.4	509	.8	3.8		.2	378	.6	3.0		.2	307
20	1.0	4.5		.4	510	.8	3.8		.2	379	.6	3.0		.2	311
21	1.0	4.5		.4	510	.8	3.8		.2	378	.6	3.0		.2	310
22	1.0	4.5		.4	510	.8	3.8		.2	378	.6	3.0		.2	311
23	1.0	4.5		.4	510	.8	3.8		.2	378	.6	3.0		.2	311
24	1.0	4.5		.4	511	.8	3.8		.2	379	.6	3.0		.2	311
25	1.0	4.5		.4	511	.8	3.8		.2	379	.6	3.0		.2	311

TABLE 4.—*Continued*

Days	Pig A, Berkshire, 3 years old					Pig B, Poland-China, 1½ years old					Pig C, Poland-China, 1 year old				
	Feeds used				Live weight	Feeds used				Live weight	Feeds used				Live weight
	Ground corn	Wheat bran	Wheat middlings	Tankage		Ground corn	Wheat bran	Wheat middlings	Tankage		Ground corn	Wheat bran	Wheat middlings	Tankage	
26	1.0	4.5		.4	510	.8	3.8		.2	378	.6	3.0		.2	310
27	1.0	4.5		.4	509	.8	3.8		.2	377	.6	3.0		.2	311
28	1.0	4.5		.4	509	.8	3.8		.2	378	.6	3.0		.2	311
29	1.0	4.5		.4	510	.8	3.8		.2	378	.6	3.0		.2	311
30	1.0	4.0		.4	510	.4	3.6		.2	378	.4	2.8		.2	311
31	1.0	4.0		.4	509	.4	3.6		.2	377	.4	2.8		.2	311
32	1.0	4.0		.4	509	.4	3.6		.2	377	.4	2.8		.2	311
33	1.0	4.0		.4	508	.4	3.6		.2	375	.4	2.8		.2	308
34	1.0	4.0		.4	508	.4	3.6		.2	374	.4	2.8		.2	307
35	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
36	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
37	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
38	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
39	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
40	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
41	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
42	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
43	1.0	4.0		.4	509	.4	3.6		.2	375	.4	2.8		.2	308
44	1.0	1.6		.3	509	.7	1.4		.2	375	.8	.7		.2	308
45	1.0	1.6		.3	508	.7	1.4		.2	374	.8	.7		.2	307
46	1.0	1.6		.3	507	.7	1.4		.2	373	.8	.7		.2	306
47	1.0	1.6		.3	504	.7	1.4		.2	371	.8	.7		.2	304
48	1.0	1.6		.3	502	.7	1.4		.2	370	.8	.7		.2	304
49	1.0	1.6		.3	500	.7	1.4		.2	367	.8	.7		.2	301
50	1.0	1.6		.3	499	.7	1.4		.2	366	.8	.7		.2	300

These quantities were obtained by using 78, 88, and 80, respectively, as the coefficients of digestibility for crude protein, carbohydrates, and ether extract, the following being the percentage composition of the feeds used:

	Crude protein	Carbohydrates	Ether extract
Corn	10.26	74.66	3.75
Wheat bran	14.62	61.93	4.25
Tankage	67.95		8.75

On the 30th day, after the amount of feed had been reduced to determine whether or not they would lose in weight, the pigs were receiving the amounts of digestible nutrients per day per 100 pounds live weight shown in Table 5.

TABLE 5.—MAINTENANCE RATION FOR SWINE AS DETERMINED IN EXPERIMENT No 2

(Expressed in pounds per day)

Weight of pigs	Feeds per head			Total feed per 100 pounds live weight	Digestible nutrients per 100 pounds live weight			
	Ground corn	Wheat bran	Tankage		Crude protein	Carbohydrate	Ether extract	Metabolizable energy, therms
A-509	1.0	4.0	.4	1.06	.139	.402	.032	1.981
B-375	.4	3.6	.2	1.12	.112	.404	.032	1.717
C-308	.4	2.8	.2	1.10	.112	.401	.032	1.600

Since on these last amounts of digestible nutrients the pigs maintained constant weight, altho at a slight reduction from that of the previous two weeks of maintenance feeding, a still further reduction in feed was made on the 44th day, as mentioned above, to approximately 0.08 pound crude protein, 0.25 pound carbohydrate, and 0.02 pound ether extract, with the result that they lost very materially in live weight.

The data in Table 5 show that the feed required for maintenance was about 1.09 pounds per day per 100 pounds live weight. This is a much larger quantity than is cited in Experiment No. 1 (0.87 pound), but it must be remembered that the ration in the second experiment was made up largely of wheat bran.

Under the heading "Digestible nutrients per 100 pounds live weight," it will be noticed that Pig A required 0.139 pound crude protein for maintenance while B and C were maintained on 0.112 pound. This difference is due to the fact that when the reduction in the feed was made on the 30th day, the ration for Pig A, thru some error in calculation, was not reduced as much as that of the others.

Whether or not the pigs would have been maintained on a slightly smaller quantity is not known, but from the foregoing results it would seem that the 0.08 pound protein, 0.25 pound carbohydrate, and 0.02 pound ether extract, to which the ration was reduced on the 44th day, was not sufficient, at least under the prevailing conditions of the experiment. This reduction, however, was of considerable magnitude.

In this second experiment the pigs were apparently maintained on a smaller quantity of nutrients than in the first one. There are a number of possible reasons for this fact. First, instead of discontinuing the experiment as soon as the pigs showed a loss in weight after the reduction in the food intake following the first maintenance trial, as was done in the first experiment, they were continued on the reduced quantities of feed for a longer time. Instead of continuing to lose in weight, the pigs, contrary to expectations, maintained constant weight for a period of ten days, which would apparently indicate that this smaller quantity of feed at this time was sufficient for maintenance. In other words, it is possible that if the first experiment had been continued longer after the reduction in the food intake had been made, the pigs later might have been able to maintain constant body weight. Second, relatively more protein was supplied in the ration of this second experiment than in that of the first experiment. This factor may have had an influence in making the ration more efficient for maintenance. Third, the pigs used in this experiment were not of the same breed, nor of the same age, weight, or condition as those used in the first experiment.

EXPERIMENT NO. 3

Two Berkshire barrows were used that were farrowed in September, 1906. During the summer of 1907, they were allowed to run on pasture with very scanty grain rations. It was thought that this treatment would get them into the best possible condition for this experiment. On November 12, 1907, they were put into their crates for the preliminary feeding. These crates were just long enough for the pigs to stand up or lie down conveniently, and were arranged so that the feces could be collected at the back end of the crate where they were dropped. The urine was collected by means of a zinc bottom inclining toward the middle and leading into a pan, placed underneath, which was enclosed so as to prevent evaporation. The front end of this sheet of metal sloped forward in order to carry away any saliva that might be dropped from the mouth of the pig. It was noticed that this occurred at times.

It is thought necessary in an experiment of this kind to keep pigs in their respective places for a considerable length of time in

order to accustom them to this manner of living, to adjust the crates properly, and to determine just the amount of feed that will be consumed readily. The experiment proper started on December 9, making a preliminary feeding period of nearly a month, and closed June 3, 1908. At the beginning of the experiment, the two pigs weighed 320 and 240 pounds respectively, and at the close, 470 and 350 pounds. The pigs were taken out of their crates twice a day for exercise.

After the pigs had been on feed from December 9, 1907, to February 21, 1908, inclusive, the maintenance periods started. The data of this part of the experiment are shown in Table 6. The feed was gradually reduced (for Pig A during two weeks' time, and for B, during four weeks' time) to approximately the maintenance quantity determined in the previous experiments, and this was fed to A for a period of four weeks and to B for a period of two weeks. Following this was a fasting period of eight days (47th to 54th day inclusive).

Following the fasting period there were ten consecutive 5-day periods, two of which are included in Table 6. During the first ten days following fasting, the pigs were fed a supposed maintenance quantity of feed, which was somewhat less than that fed previous to the fasting period. The entire quantity of water fed to these pigs was given to them in their slop and was more or less constant. On several occasions they were offered water to drink, but refused to take any.

All feeds used were analyzed, and both feces and urine were subjected to a complete chemical analysis to determine as nearly as possible the total amount and the nature of the metabolism that takes place in a pig under these various conditions.

EXPERIMENTAL DATA

The following table gives a complete record of the feeds and water consumed by the pigs daily, and also their daily live weights for the part of the experiment that pertains to the subject in hand.

It will be seen from this table that both pigs made some gain in live weight during the first twelve days of this part of the experiment, and that Pig B continued to make gains up to the 24th day, while A remained practically constant. This difference was due to the fact, as stated above, that the ration for Pig A was reduced more rapidly than that for Pig B. At about the 28th day (Period 10) the rations for both pigs had been reduced to a quantity that was supposed to be a maintenance ration, and the live weights

TABLE 6.—DAILY WEIGHTS OF PIGS AND FEEDS FOR THE THIRD MAINTENANCE EXPERIMENT

(Expressed in pounds)

Days	Periods	Pig A						Pig B					
		Feeds used					Live weight	Feeds used					Live weight
		Ground corn	Red dog flour	Tank-age	Pork crack-lings	Water		Ground corn	Red dog flour	Tank-age	Pork crack-lings	Water	
1		4.8		1.2	.4	10	420	3.6		.9	.4	9	322
2		4.8		1.0	.4	10		3.6		.8	.4	9	
3		3.4	.8	1.0	.3	10		2.6	.6	.8	.4	9	
4		3.0	.8	.9	.3	10		2.6	.6	.8	.4	9	
5		3.2	.8	.9	.3	10		2.5	.6	.7	.4	9	
6		3.1	.8	.8	.3	10	423	2.5	.6	.7	.4	9	325
7	7	3.0	.8	.8	.3	10		2.4	.6	.7	.4	9	
8		2.9	.8	.7	.3	10		2.4	.6	.7	.4	9	
9		2.8	.8	.7	.2	10	428	2.3	.6	.7	.4	9	331
10		2.6	.8	.6	.2	10	429	2.3	.6	.6	.4	9	330
11		2.4	.8	.6	.2	10	430	2.2	.6	.6	.3	9	331
12		2.2	.8	.5	.2	10	430	2.2	.6	.6	.3	9	331
13		2.0	.8	.4	.2	10	430	2.1	.6	.6	.3	9	332
14	8	1.8	.8	.4	.2	10	430	2.1	.6	.6	.3	9	333
15		1.6	.8	.3	.2	10	429	2.0	.6	.5	.3	9	331
16		1.6	.8	.3	.2	10	428	2.0	.6	.5	.3	9	334
17		1.6	.8	.3	.2	10	430	1.9	.6	.5	.3	9	332
18		1.6	.8	.3	.2	10	430	1.9	.6	.5	.3	9	333
19		1.6	.8	.3	.2	10	431	1.8	.6	.4	.3	9	334
20		1.6	.8	.3	.2	10	430	1.8	.6	.4	.3	9	334
21	9	1.6	.8	.3	.2	10	430	1.7	.6	.4	.3	9	335
22		1.6	.8	.3	.2	10	430	1.7	.6	.4	.2	9	336
23		1.6	.8	.3	.2	10	430	1.6	.6	.3	.2	9	335
24		1.6	.8	.2	.2	10	431	1.6	.6	.3	.2	9	336
25		1.6	.8	.2	.2	10	431	1.4	.6	.3	.2	9	336
26		1.6	.8	.2	.2	10	431	1.4	.6	.3	.2	9	336
27		1.6	.8	.2	.2	10	431	1.3	.6	.2	.2	9	336
28	10	1.6	.8	.2	.2	10	431	1.3	.6	.2	.2	9	336
29		1.6	.8	.2	.2	10	431	1.2	.6	.2	.2	9	336

TABLE 6.—*Continued.*

30		1.4	.8	.2	.2	10	431	1.2	.5	.2	.2	9	338
31		1.3	.7	.2	.2	10	431	1.1	.5	.2	.2	9	336
32		1.2	.6	.2	.2	10	431	1.0	.4	.2	.2	9	336
33		1.2	.6	.2	.2	10	430	.9	.4	.2	.2	9	335
34		1.2	.6	.2	.2	10	430	.9	.4	.2	.2	9	335
35	11	1.2	.6	.2	.2	10	431	.9	.4	.2	.2	9	337
36		1.2	.6	.2	.2	10	431	.9	.4	.2	.2	9	336
37		1.2	.6	.2	.2	10	431	.9	.4	.2	.2	9	336
38		1.0	.6	.2	.2	10	431	.8	.3	.2	.2	9	335
39		1.0	.6	.2	.2	10	430	.8	.3	.2	.2	9	335
40		1.0	.6	.2	.2	10	430	.8	.3	.2	.2	9	335
41		1.0	.6	.2	.2	10	430	.8	.3	.2	.2	9	335
42		1.0	.6	.2	.2	10	429.5	.8	.3	.2	.2	9	334.5
43		1.0	.6	.2	.2	10	427	.8	.3	.2	.2	9	332.5
44		1.0	.6	.2	.2	10	429	.8	.3	.2	.2	9	333.5
45	12	1.0	.6	.2	.2	10	427.5	.8	.3	.2	.2	9	334
46		1.0	.6	.2	.2	10	427	.8	.3	.2	.2	9	332
47						4	427					6.4	332
48						3.8	422.5					3.1	331.5
49						2	421					2.6	328
50	13					3.2	420.5					2.7	321
51						1.3	419					2.0	324
52						1.2	415					5.5	321.5
53						3.6	416					2.5	322
54						1.4	416					4.7	321.5
55		.8	.6	.2	.2	10	414	.8	.2	.2	.2	9	318
56		.8	.6	.2	.2	10	414	.8	.2	.2	.2	9	319
57	14[1]	.8	.6	.2	.2	10	415	.8	.2	.2	.2	9	319.5
58		.8	.6	.2	.2	10	415.5	.8	.2	.2	.2	9	321
59		.8	.6	.2	.2	10	416	.8	.2	.2	.2	9	319
60		.8	.6	.2	.2	10	416	.8	.2	.2	.2	9	320.5
61		.8	.6	.2	.2	10	416	.8	.2	.2	.2	9	319
62	15	.8	.6	.2	.2	10	415	.8	.2	.2	.2	9	318
63		.8	.6	.2	.2	10	416	.8	.2	.2	.2	9	319.5
64		.8	.6	.2	.2	10	415.5	.8	.2	.2	.2	9	321

[1]Period 14 for Pig B includes only 3 days, *i. e.*, Nos. 57, 58, and 59.

were apparently maintained. Following Period 10, the ration were still further reduced to make sure that they would be low enough. The pigs maintained fairly constant live weight on the reduced quantity of nutrients until about the 42d day, after which there was a tendency for them to lose in live weight. This would seem to indicate that the amounts of feed given at this time supplied a quantity of nutrients that might be a little below the maintenance requirement.

During the fasting period the pigs lost steadily in live weight. Following this period they were given less food for a period of ten days than they had received just previous to it. Nevertheless, they maintained fairly constant live weight.

All this seems to indicate very strongly that the maintenance requirement of swine is not constant but varies under different conditions. When the ration is reduced, the maintenance requirement also seems to become lowered.

TABLE 7.—PERCENTAGE COMPOSITION OF FEEDS

(Grindley and Emmett, Analysts)

Feed	Water	Crude protein	Carbo-hydrate	Ether extract	Ash	Nitro-gen	Phos-phorus
			Before Fasting				
Ground corn	13.40	8.69	73.98	2.76	1.38	1.391	.26
Red dog flour.....	11.59	17.87	73.81	1.55	3.54	1.498	.81
Tankage	7.09	58.90	10.13	14.23	9.63	9.424	1.27
Pork cracklings ...	4.89	54.17	2.00	35.67	2.00	8.669	.27
			After Fasting				
Ground corn	14.16	8.33	73.29	2.88	1.32	1.333	.253
Red dog flour.....	11.82	17.86	73.74	1.55	3.54	1.497	.800
Tankage	9.19	57.57	9.91	13.91	9.42	9.211	1.240
Pork cracklings ...	5.41	53.88	1.99	36.72	2.00	8.622	.265

Table 7 gives the percentage composition of the various feeds that were used during the maintenance portion of the experiment. In general, it should be noted that red dog flour contains about twice as much crude protein as does ground corn, and that it contains considerably less ether extract and a great deal more ash and phosphorus. Tankage contains less water than either ground corn or red dog flour. It contains a very high percentage of crude protein besides considerable ether extract, and is high in ash and phosphorus also. Pork cracklings are comparable to tankage in crude protein, but they contain very much more ether extract and less ash and phosphorus. The phosphorus content of cracklings is practically the same as that of ground corn.

TABLE 8.—MAINTENANCE RATION FOR SWINE AS DETERMINED IN EXPERIMENT NO. 3.

(Expressed in pounds per day)

Days	Periods	Pigs	Live weight	Feeds for maintenance				Water	Total feed per 100 pounds live weight	Digestible nutrients per 100 pounds live weight				
				Ground corn	Red dog flour	Tankage	Pork cracklings			Crude protein	Carbohydrate	Ether extract	Water	Metabolizable energy, therms
Before Fasting														
27–29	10	A	431	1.6	.8	.2	.2	10	.65	.094	.376	.038	2.42	1.697
"	10	B	336	1.3	.6	.2	.2	9	.67	.106	.376	.038	2.76	1.595
34–36	11	A	431	1.2	.6	.2	.2	10	.46	.078	.252	.029	2.37	1.206
"	11	B	336	.9	.4	.2	.2	9	.51	.090	.264	.035	2.75	1.213
43–46	12	A	427	1.0	.6	.2	.2	10	.47	.079	.254	.029	2.42	1.210
"	12	B	332	.8	.3	.2	.2	9	.45	.084	.227	.034	2.79	1.080
After Fasting														
55–59	14	A	415.3	.8	.6	.2	.2	10	.43	.070	.228	.029	2.46	1.117
57–59	14	B	319.8	.8	.2	.2	.2	9	.44	.084	.213	.036	2.86	1.040
60–64	15	A	415.7	.8	.6	.2	.2	10	.43	.078	.228	.029	2.46	1.117
"	15	B	319.5	.8	.2	.2	.2	9	.44	.084	.213	.036	2.86	1.040

The coefficients of digestibility used in calculating the amounts of digestible nutrients consumed were determined during the progress of the experiment. They are approximately as follows: crude protein, 80; carbohydrate, 90; ether extract, 90. On this basis the two pigs were receiving, during the maintenance periods, the amounts of feeds and digestible nutrients recorded in Table 8.

As will be seen from Table 8, these pigs received very small quantities of total feed during the maintenance periods. During Period 10, when they maintained constant live weight, they received 0.65 and 0.67 percent of feed respectively, based on their live weights. During Period 11, when they maintained their live weights equally well, these quantities had been reduced to 0.46 and 0.51 percent respectively. These quantities were still further reduced during Period 12, but the pigs did not maintain their live weights. After fasting, the two pigs received only 0.43 and 0.44 percent of feed respectively, and maintained their live weights after gaining a little immediately following the period of fasting.

During Period 10, when the pigs were maintaining their live weights, they were receiving an average of 0.1 pound of digestible crude protein, 0.376 pound of digestible carbohydrates, and 0.038 pound of digestible ether extract. During Period 11 these quantities had been reduced to: crude protein, 0.084; carbohydrate, 0.258; and ether extract, 0.032; and still the pigs were maintaining their live weights. During Period 12 the pigs lost a little in live weight; consequently the nutrients they received at that time are not considered sufficient for maintenance under the conditions of the experiment then existing. After the period of fasting, they received the following amounts of digestible nutrients: protein, 0.079; carbohydrate, 0.221; and ether extract, 0.033. These quantities are considerably lower than those of any previous period of this experiment and decidedly lower than those of either of the two previous experiments; but still the pigs maintained their live weights.

Table 10 gives the percentage composition of the fresh feces and urine. The data show that the feces of Pig A contained more water than those of Pig B, but that the feces of Pig B contained a higher percentage of crude protein and of carbohydrates than did those of Pig A.

Table 11, giving the percentage chemical composition of the water-free feces, shows that before fasting, the feces of Pig A contained less crude protein and more ash than those of Pig B, and that in ether extract and carbohydrate the feces of the two pigs were quite comparable but that the quantities appearing in the

TABLE 9.—WEIGHTS OF PIGS, FEEDS, AND EXCRETA FOR THE THIRD MAINTENANCE EXPERIMENT

(Expressed in pounds per period)

Days	Periods	Pigs	Weight	Feed Eaten					Excreta	
				Ground corn	Red dog flour	Tankage	Crack-lings	Water	Urine	Feces
Before Fasting										
27–29	10	A	431	4.8	2.4	.6	.6	30	26.09	3.06
"	10	B	336	3.8	1.8	.6	.6	27	17.20	2.51
34–36	11	A	431	3.6	1.8	.6	.6	30	25.73	2.81
"	11	B	336	2.7	1.2	.6	.6	27	20.93	1.55
43–46	12	A	427	4.0	2.4	.8	.8	40	37.44	2.67
"	12	B	332	3.2	1.2	.8	.8	36	31.93	1.93
After Fasting										
55–59	14	A	415.3	4.0	3.0	1.0	1.0	50	39.45	1.01
57–59	14	B	319.8	2.4	.6	.6	.6	45	18.72	1.27
60–64	15	A	415.7	4.0	3.0	1.0	1.0	50	42.06	4.14
"	15	B	319.5	4.0	1.0	1.0	1.0	45	34.28	1.82

TABLE 10.—PERCENTAGE COMPOSITION OF THE FRESH FECES AND URINE

(Grindley and Emmett, Analysts)

Days	Period	Pig	Water	Crude protein	Ether extract	Carbo-hydrate	Ash	Nitrogen		Phosphorus	
								Feces	Urine	Feces	Urine
Before Fasting											
27–29	10	A	66.12	9.70	1.81	17.27	5.10	1.552	.717	.84	.048
"	10	B	62.46	11.78	2.31	18.28	5.15	1.885	1.001	.74	.068
34–36	11	A	63.83	10.89	2.41	17.04	5.83	1.743	.769	.87	.044
"	11	B	56.22	13.63	2.29	20.89	6.97	2.181	.784	1.00	.041
43–46	12	A	63.52	11.29	1.96	16.79	6.44	1.807	.672	.97	.034
"	12	B	58.34	14.81	1.73	18.54	6.58	2.367	.646	.97	.028
After Fasting											
55–59	14	A	57.37	10.92	2.69	19.15	9.87	1.748	.560	1.41	.015
57–59	14	B	52.84	14.98	2.77	20.92	8.49	2.396	.472	1.23	.012
60–64	15	A	63.29	10.47	1.56	17.04	7.64	1.676	.600	1.02	.025
"	15	B	56.40	15.11	1.41	20.89	6.19	2.418	.581	.87	.021

different periods were somewhat variable. It also shows that after fasting, as well as before, the feces of Pig A contained less crude protein and more ash than those of Pig B. In carbohydrate content the feces of the two pigs were practically the same.

TABLE 11.—PERCENTAGE COMPOSITION OF THE WATER-FREE FECES
(Grindley and Emmett, Analysts)

Days	Period	Pig	Crude protein	Ether extract	Carbo-hydrate	Ash
			Before Fasting			
27–29	10	A	28.63	5.34	50.98	15.05
"	10	B	31.38	6.15	58.69	13.78
34–36	11	A	30.11	6.66	47.11	16.12
"	11	B	31.13	5.23	47.72	15.92
43–46	12	A	30.95	5.37	46.03	17.65
"	12	B	35.53	4.15	44.52	15.80
			After Fasting			
55–59	14	A	25.62	6.31	44.92	23.15
57–59	14	B	31.76	5.87	44.37	18.00
60–64	15	A	28.52	4.25	46.42	20.81
"	15	B	34.66	3.23	47.91	14.20

Table 12 gives the nitrogen balance, and the water balance as far as it could be determined from the feces and urine alone without the use of a respiration calorimeter.

TABLE 12.—BALANCES FOR WATER, NITROGEN, PROTEIN, AND BODY TISSUE
(Expressed in pounds per day per 100 pounds live weight)

Days	Period	Pig		Water	Nitrogen	Protein (Nx6.25)	Body tissue (protein x 4)
		Name	Weight				
				Before Fasting			
27–29	10	A	431	.2471	.0007	.0044	.0175
"	10	B	336	.9292	.0007	.0044	.0175
34–36	11	A	431	.2726	.0028	.0155	.0620
"	11	B	336	.5916	.0017	.0108	.0432
43–46	12	A	427	.1195	.0020	.0134	.0536
"	12	B	332	.2830	.0023	.0144	.0576
				After Fasting			
55–59	14	A	415.3	.5349	.0040	.0249	.0996
57–59	14	B	319.8	.8640	.0041	.0256	.1024
60–64	15	A	415.7	.3209	.00004	.0003	.0012
"	15	B	319.5	.6956	.0013	.0081	.0324

The data of Table 12 show that both pigs maintained plus nitrogen balances during Periods 10, 14, and 15, with the exception that Pig A had a very small minus balance during Period 15, so small, however, that it is practically negligible. This shows that the pigs at these times had sufficient protein in their ration for

maintenance. During Periods 11 and 12 there was not enough protein in the ration to maintain nitrogen equilibrium under the existing conditions. Since the pigs received practically the same quantity of protein during Periods 14 and 15 (after fasting) as they did during Periods 11 and 12 (before fasting), it is evident that the fasting period exerted an influence upon the maintenance requirement. It seemingly had the effect of making the pig a somewhat more economical machine.

GENERAL DISCUSSION

One of the most obvious facts brought out by the data presented in this bulletin is the apparent variability in the maintenance requirement of swine.

In the first experiment, the 50-pound pigs were practically maintained in live weight from the 11th to the 15th day of the experiment, inclusive. From the 24th to the 27th day inclusive, when they were fed only about 60 percent of the quantity of feed given them during the period mentioned above, they fully maintained their live weights; in fact, they gained on an average ½ pound during the 4-day period, while during the former 5-day period they gained on an average only ¼ pound. With a still further reduction in feed to somewhat less than half the quantity which they received from the 11th to the 15th day inclusive, they again maintained their live weights. However, it should be noted in this connection that these same pigs, when they weighed 100, 150, and 200 pounds, did not exhibit this apparent variability in maintenance requirements. It is possible that this difference in behavior was due to the fact that in the latter case the rations were reduced more rapidly; also that each of the latter periods was preceded by a maintenance period lasting for a few weeks.

In the second experiment, the pigs maintained their live weights very constant from the 19th to the 29th day inclusive. With a reduction in the feed amounting to about 11 percent on the 30th day, they again maintained their live weights on the reduced quantity of feed beginning with the 33rd day.

In the third experiment, the pigs maintained their live weights during several different periods from the 27th to the 64th day of the experiment, on distinctly different quantities of feeds.

The author as yet has found no reference to other maintenance experiments upon pigs in which, after the apparent maintenance ration was found, the effects of a further reduction in the ration upon the live weight were determined. The experimental data here given clearly show that the live weight of one and the same pig may be maintained at different times and under different conditions upon distinctly different quantities of food nutri-

ents. The results indicate that the pigs, after being kept for some time upon a maintenance ration, get into such condition that they can utilize the food constituents to better advantage for purposes of maintenance than they can when given larger quantities of the same feed preceding the maintenance period.

This finding with regard to swine is in agreement with the results obtained by Waters[1] in experiments with steers, from which he draws the following conclusions: "Apparently the animal organism (steers), when kept for a long period of time on a low nutritive plane, as in the case of maintenance animals, gets on a more economical basis than when more liberally fed. For example, if we reduce the feed of an animal that has been previously liberally nourished, to a point where for a month or more there is a small loss in weight, an equilibrium will later be established and subsequently the animal may increase in weight, the quantity and quality of the food remaining the same. Thus, a ration that was insufficient to sustain live weight at first may be capable later of maintaining the animal at a stationery body weight, and still later of causing an increase in weight. Digestion experiments with a number of animals indicate that a part of this is due to the more complete digestion of the food by the animal on a low nutritive plane, but so far as the experiments have thus far progressed there does not seem to have been a sufficient increase in the degree to which the food has been digested to account for all the increased efficiency in the ration noted."

The results obtained with the pigs are also in accord with those obtained by Mumford, Grindley, Hall, and Emmett in an extended investigation[2] by this department in which it has been clearly demonstrated that steers kept upon a maintenance ration utilize their feed more completely than do full-fed steers; and further, that steers kept continually upon maintenance for a long period of time become more and more economical, or in other words, they gradually get into such a condition that they can maintain themselves upon smaller and smaller quantities of the same feed.

On the other hand, it is not apparent from the digestion experiments that were made in connection with these maintenance experiments that these pigs, when upon a maintenance ration, digested significantly greater quantities of the food nutrients than they did when given a full-feed allowance. A further discussion of the probable explanation for this apparent variability in the utilization of food by pigs will be considered in a subsequent bulletin.

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[1]Proc. Soc. Prom. Agr. Sci., 1908.

[2]Unpublished manuscript of the Department of Animal Husbandry, University of Illinois.

As seen from the data of the first experiment given in Table 3, page 417, pigs of the same mixed breeding, ranging in weight from 50 to 150 pounds live weight, were maintained on 0.12 to 0.13 pound of digestible crude protein, 0.43 to 0.62 pound of digestible nitrogen-free extract, 0.006 to 0.011 pound of crude fiber, and 0.020 to 0.033 pounds of ether extract, daily, per 100 pounds live weight. The 200-pound pigs were not quite maintained on 0.10 pound of crude protein, 0.54 pound of nitrogen-free extract, 0.01 pound of crude fiber, and 0.033 pound of ether extract. The metabolizable energy required for maintenance by the 50-, 100-, 150-, and 200-pound pigs were 0.897, 1.317, 1.806, and 1.718 therms respectively. From these figures it seems apparent that as these pigs (excepting the 200-pound animals, for the reason mentioned immediately above) increased in age and in weight under the conditions of a widening nutritive ratio of the rations, there was an increase in the quantities of food nutrients required to maintain their live weights. The 100-pound pigs apparently required for maintenance 2.5 percent more crude protein, 19 percent more nitrogen-free extract, 33.3 percent more crude fiber, 30 percent more ether extract, and 47 percent more metabolizable energy than did the 50-pound pigs. Further, the ration which maintained the 150-pound pigs contained 5.7 percent more crude protein, 25.5 percent more carbohydrates, 37.5 percent more crude fiber, 26.9 percent more ether extract, and 37 percent more metabolizable energy than the ration which maintained the 100-pound pigs. These results are in accord with those of other investigators, and seem to show, in general, that younger pigs require less for maintenance per 100 pounds live weight than do older ones. However, as Armsby points out, this may be due to the fact that the maintenance of live weight in a young animal is not necessarily synonymous with the maintenance of its store of potential energy. It is possible that the above-mentioned increase in the food required for maintenance in the successive periods as the pigs grew older was due to the fact that the nutritive ratio of the rations for the successive periods was gradually widened. However, further investigation will be necessary in order to determine this point.

In the second experiment, one Berkshire pig 3 years old, weighing approximately 510 pounds, and two Poland-China pigs, one 1½ years old, weighing approximately 375 pounds, and the other, 1 year old, weighing 310 pounds, fed upon the same feeds, but in different proportions, were maintained on 0.14, 0.11, and 0.11 pound, respectively, of digestible crude protein, 0.402, 0.404, and 0.401 pound of digestible carbohydrates, 0.032 pound of digestible ether extract each, and about 1.766 therms of metabolizable energy. The maintenance requirements for these three pigs were remarkably

similar with one exception, *i. e.,* the crude protein for the Berkshire animal, which apparently required 24.1 percent more protein than either of the other two animals. There were so many variables in this experiment that may be of significance that it is not wise to draw definite conclusions from the results until further experiments are made along these same lines. It should be noted also that the maintenance requirements obtained in this experiment are, in general, quite similar to those obtained in the first experiment, especially with regard to the 50-pound pigs, notwithstanding the fact that the breed, age, and weight of the pigs were different, and that the kinds and quantities of the feeds and the nutritive ratio of the rations also were different in the two experiments.

In the third experiment, of two Berkshire barrows of the same age (16 months), one weighing approximately 430 pounds and the other 330 pounds, fed upon the same kinds of feeds but in different proportions, the former apparently required for maintenance 0.078 pound of protein, 0.228 pound of carbohydrates, 0.029 pound of ether extract, and about 1.117 therm of metabolizable energy. It seems from this data that the maintenance requirement of the heavier animal was somewhat less than that of the lighter animal. The difference, however, is small and is believed by the writer to be within the limits of experimental error and the power of the pig to adapt itself to the conditions supplied. It should be observed that the maintenance requirements obtained in this experiment were distinctly lower than those obtained in the first and second experiments. At present the cause of this difference is not entirely apparent from the experimental data available. It is possible that one or more of the following factors was instrumental in leading to the lower results found in the last experiment. In this third experiment the pigs had been maintained for a longer time on a low nutritive plane before the final maintenance test was made than was the case in the two former experiments. The feeds also differed in part from those used in the other experiments, *i. e.,* there was more variety, and pork cracklings were used in this last experiment but not in either of the first two. Also, as previously discussed, relatively more protein was fed. The specific effects of the feeds may have played some part in yielding the variable results obtained in the experiments here reported.

The writer believes, judging from the general trend of the results of this series of experiments, that under uniform conditions the actual minimum maintenance requirement per 100 pounds live weight is fairly constant for pigs of different ages and breeds. This, of course, would not hold true for pigs in different degrees of condition, *i. e.,* the fatter pig would require relatively less for maintenance than the leaner one. This entire question of variability

in the food requirement of pigs will be given further attention in a future bulletin from this department.

CONCLUSIONS

1. The results of the experiments here reported indicate that the maintenance requirement of pigs is variable, *i. e.*, one and the same pig, under different conditions, may maintain its live weight on distinctly different quantities of the same combination of feeds. This variation seems to be due to the plane of nutrition upon which the pigs have been maintained previous to the time of making the maintenance experiment.

2. The results also indicate that the maintenance requirement of pigs which previously have been kept on a low nutritive plane may be reduced to the following weights of nutrients per 100 pounds live weight: digestible crude protein, 0.10 pound; digestible carbohydrates, 0.25 to 0.40 pound; digestible ether extract, 0.03 pound. The calculated energy requirement for the above maintenance ration on the same basis would be about 1.12 therms.

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